THE LIFE-HISTORY OF HISTIOSTOMA POLYPORI (OUD.) (ACARI: TYROGLYPHOIDEA)*

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INTRODUCTION

Specimens of the common European earwig, *Forficula auricularia* Linn., taken from the field in Edinburgh (Scotland) and reared on a medium of soil and vegetable food, often acquired heavy infections of the hypopi of the Tyroglyphoid mite *Histiostoma polypori* (Oud.). Apart from a casual reference to the mite and an insufficient description of the hypopus stage by Oudemans (1914) under the name of *Anoetus polypori*, nothing was practically known about the mite (Behura, 1950). The author (Behura, 1955) has dealt with the history and taxonomy of the mite and in this paper, endeavours to give an account of the life-history of the much obscure mite.

METHODS

The mites were reared in special cells designed, but with some modifications on the lines of those described by Robertson (1944). The cell consisted of a black perspex plate 4 cm. square and 0.3 cm. thick, having a central circular aperture with an inclined wall. A piece of black filter paper, fixed with a gum covered the space at its narrow diameter of 1.7 cm. and served as the porous base of the cell. The cell was completely closed by placing a coverglass, 3.5 cm. square, over the cell at its wider diameter of 2.4 cm. To prevent the escape of the minute larvae of a culture, the coverglass was sealed to the perspex plate with a thin smear of petroleum jelly.

A high moisture content, necessary for providing the most favorable conditions for culturing the mites was maintained by placing the filter paper base upon cotton wool, moistened with water, enclosed in a glass trough. The glass trough, containing the cells, could then be exposed to the required temperature. It

* This paper formed part of the thesis presented to the University of Edinburgh, Scotland, for the degree of Ph.D.

was found that the mites, including larvae introduced into the cells, moved slowly but quite easily over a filter paper base saturated with moisture.

The mites were literally submerged as they fed upon the liquefied decomposing food placed in the cell, e.g. small pieces of earwigs, decaying cabbage, dandelion floral parts, etc. Mites fed on horse flesh attained sizes about twice those of comparable stages of mites cultured on a diet of decomposing earwig remains.

Introduced mites will remain upon the decomposing food, either submerged and immobile, or slowly and laboriously moving to and fro in the liquefied mass. They will soon multiply, the eggs being usually laid in masses around the periphery of the food material, although they are also indiscriminately laid either singly or in small groups on the food itself or upon the filter paper at a relatively short distance from the food. The design of the cell made it very easy to observe the movements of a culture of mites under a binocular microscope. The moisture content of the cell was maintained by mounting the cell upon a solid watch glass containing moist cotton wool. Overhead or lateral illumination of the cell when viewed under the binocular microscope readily accentuated the contrast of the opaque mites against the black back-ground. The transparent nature of the cuticle also made observations of transition stages easy and it was possible to distinguish readily the newly forming stage within the cuticle of the preceding one. Immobilization of the mite was usually a prelude to the extensive histolytic processes which affected the soft organs and tissues of the body.

To follow in detail the stages of the life-cycle, a male and a female were transferred to a single cell. As the eggs were laid and when a sufficient number were counted, the adults were removed. In this way as many cells as could be examined by one observer were stocked with newly-laid eggs. As the larvae emerged they were transferred to separate cells and their progress of development to the adult stage carefully recorded. It was therefore possible to follow the life-cycle of separate individuals under standard conditions.

The cell design also made it very easy to expose the mites to varying humidities and different temperatures.

The laboratory cultures of *H. polypori* if left unattended for

some time, occasionally became contaminated with the Tyroglyphoid mite *Tyroglyphus siro* Linne. *T. siro* requires less humidity than *H. polypori* for growth. As the moisture content decreased in the petri dish or bottle cultures, *T. siro* became dominant and the numbers of *H. polypori* gradually grew less. Some of the stock cultures in glass vials and petri dishes were ruined by heavy infection of *T. siro*.

A species of small fungus gnat also laid eggs in the stock cultures. Even when the large petri dishes are closed with glass covers, the slender dipterons find a way into the culture to lay eggs. The large elongate vermiform larvae with their black heads are voracious feeders and they will eat the *Forficula* remains, decaying vegetable matter, and even the filter paper. Mr. H. Oldroyd of the British Museum kindly identified the specimens as a species of *Sciara* of the family *Mycetophilidae*.

LIFE-HISTORY

Mating:

Mating in *H. polypori* is very peculiar. Active deutonoymphs at an advanced stage of development are easily distinguishable as males or females. The "female" deutonymphs before passing to the resting stage carry adult males. The position of the male resembles that found in the insects, since it clasps the dorsoposterior part of the female's body. The well-developed legs of the male allow it to take a firm hold of the deutonymph. After a short period of activity, the deutonymph passes to the transition or resting stage. The male will remain attached to the resting "female deutonymph," while other males will attempt to dislodge it. The hold of the male is so firm that it will cling to the deutonymph even when both are rolled somewhat vigourously. Presumably, mating takes place immediately after the emergence of the female from the nymphal skin.

If for some reason or other, the "female" deutonymph does not hatch into the adult condition, but dies, even then the male remains clasping it for a considerable time. In one instance, the attachment lasted continuously for 11 days and discontinuously for another 3 days. This was more interesting from the fact that this male even when dislodged would mount on the "female" and attain the usual posture again.

It would therefore appear that the males have acquired the instinct of distinguishing an active or resting "female" deutonymph. I am not aware of this mating behaviour occurring among other members of the Tyroglyphoidea. Stolpe (1938), who worked on the life-history of *H. genetica* Stolpe, the hypopi of which heavily infest laboratory cultures of *Drosophila melanogaster,* recorded the mating behaviour of adults. Jary *et al* (1936), who studied the life-history of *H. rostro-serratum* Mégnin, apparently discovered no unusual mating behaviour.

Occasionally, however, males were found attached to resting

TABLE 1

PRE-OVIPOSITION PERIOD AND NUMBER OF EGGS LAID BY FERTILIZED AND PARTHENOGENETIC FEMALES OF *Histiostoma polypori* AT LABORATORY TEMPERATURES AND 100% RH.

Serial No.	Date on which ♀ emerged	Fertilized (F) or unfertilized (UF)	Time in hours taken between maturity of ♀ and egg-laying	No. of days eggs laid continuously	Total No. of eggs laid
1	October 4, 1948	F	30	.....	50
2	Nov. 16, 1948	UF	90	.....	20
3	Nov. 12, 1948	F	.....	.....	89
4	Jan. 6, 1949	F	.....	6	80
5	Jan. 10, 1949	F	108	.....	.....
6	Jan. 11, 1949	UF	24	.....	.....
7	Jan. 11, 1949	UF	29	.....	36
8	Jan. 11, 1949	F	84	.....	.....
9	Jan. 11, 1949	F	40	.....	40

"male" deutonymphs. Sometimes they will apply themselves to gravid females which actively protest against the attachment and the male soon falls off. The observations imply that the male will assume attachment as an inherent response to the touch of a female mite's body, but the explanation could not account for males confining their attention only to "female" deutonymphs in readiness for the emerging female.

Oviposition:

At the laboratory temperatures in the month of January, 1949, eggs were laid 24 to 108 hours after mating. The average time taken was 57 hours. At a temperature of 26° C ± 1° C and

100% RH, the fertilized female will lay from 40 to 110 eggs (Tables 1 and 2).

The eggs are very hygroscopic, transparent and not always easy to find even under the binocular microscope. In reflected light, however, the eggs impart a greenish tinge which makes their

TABLE 2

PRE-OVIPOSITION PERIOD AND NUMBER OF EGGS LAID BY FERTILIZED AND PARTHENOGENETIC FEMALES OF *Histiostoma polypori* AT 26° C ± 1° C., 100% RH.

Serial No.	Date on which ♀s emerged	Fertilized (F) or unfertilized (UF)	Time in hours taken between maturity of ♀ and laying of 1st batch of eggs	Number of days eggs laid continuously	Total number of eggs laid
1	March 30, 1949	F	18	5	40
2	April 1, 1949	UF	20	6	136
3*	April 7, 1949	UF	14	.....	9
4	April 5, 1949	UF	14	.....	50
5	April 6, 1949	UF	8	.....	30
6	April 6, 1949	UF	14	4	80
7	April 2, 1949	UF	10	4	70
8	April 6, 1949	UF	16	6	90
9*	April 23, 1949	UF	.....	.....	6
10	April 6, 1949	UF	18	6	110
11	April 30, 1949	UF	18	10	120
12 (exception)	March 31, 1949	F	120	.....	110
13	April 11, 1949	UF	18	.....	50
14	April 1, 1949	UF	.....	.....	110
15	April 1, 1949	UF	16	7	95
Average			15		74

detection easier, but if the filter paper is too moist the eggs merge with the water film. When the excess moisture is allowed to evaporate, the eggs are contrasted against the black filter paper as well-defined oval bodies, partly opaque and partly transparent.

Oviposition lasts about 4 to 6 days but occasionally continues for about 10 days (Table 2).

Incubation:

At the laboratory temperature of January 1949, at 100% RH, the incubation period ranged from 28 to 110 hours with an average of 85 hours. In November, 1948, the period of incubation

was 28 to 96 hours with an average of 50 hours, owing to warmer temperatures, compared with those of January (Table 3). At a constant temperature of 26° C ± 1° C and 100% RH, the incubation period ranged from 13 to 40 hours with an average of 20.5 hours (Table 4).

The eggs, about 84μ × 59μ, are light and float in water. By the end of the incubation period the eggs owing to inhibition of water increase to about 126μ × 84μ. The first visible change in the egg was the appearance of the white material to one side of the egg. The transparent chorion of the egg allowed an examination of the developing larva to be made (Text-fig. 1). This was best seen

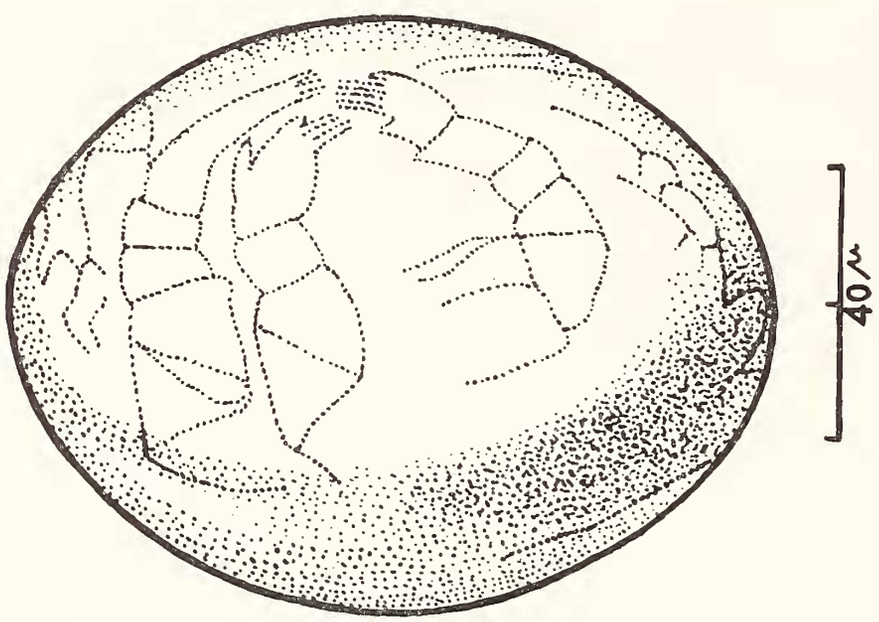

Fig. 1. *Histiostoma polypori.* Embryo as seen through the egg-case.

by mounting eggs in lactic acid or water or a preparation of Polyvinyl alcohol.

Emergence of Active Stages:

The actual emergence of the larva from the egg was never observed. However, the emergence of the nymph and adults and that of the specialized hypopus from the resting protonymphs were observed.

The emergence of the newly-formed nymph or adult from the cuticle of the preceding stage follows the same pattern. Before the preceding stage becomes immobile there are already signs of differentiation taking place. Thus the resting stage of the mite

TABLE 3

THE INCUBATION PERIODS OF FERTILIZED AND PARTHENOGENETIC EGGS OF *Histiostoma polypori* AT THE LABORATORY TEMPERATURE AND 100% RH.

Serial No.	Date on which eggs were laid	Fertilized (F) or un-fertilized (UF)	Duration of incubation in hours
1	November 16, '48	UF	96
2	November 16, '48	F	34
3	November 11, '48	F	28
4	November 11, '48	F	96
5	January 6, '49	F	28
6	January 10, '49	F	60
7	January 11, '49	F	100
8	January 11, '49	F	96
9	January 11, '49	F	110
10	January 15, '49	.....	96
11	January 15, '49	.....	108
12	January 20, '49	F	84
13	January 20, '49	F	84
Average (January, 1949)			85

TABLE 4

THE INCUBATION PERIODS OF FERTILIZED AND PARTHENOGENETIC EGGS OF *Histiostoma polypori* AT 26° C ± 1° C, 100% RH.

Serial No.	Fertilized (F) or Un-fertilized (UF)	Duration of incubation in hours
1	F	18
2	F	24
3	F	24
4	UF	14
5	UF	10
6	UF	13
7	UF	17
8	UF	30
9	UF	20
10	UF	20
11	F	16
12	UF	40
Average		20½

is already recognized. The soft parts of the body retreat from the legs and the proterosoma, which become transparent. Histolytic processes are responsible for the breakdown of the organs and tissues, followed by a re-differentiation of the mass into organs of the next stage. The new stage forms at the posterior region, the legs are folded inside the old cuticle and do not protrude into the cuticle of the legs of the preceding stage. As a prelude to emergence, the newly formed stage becomes very active

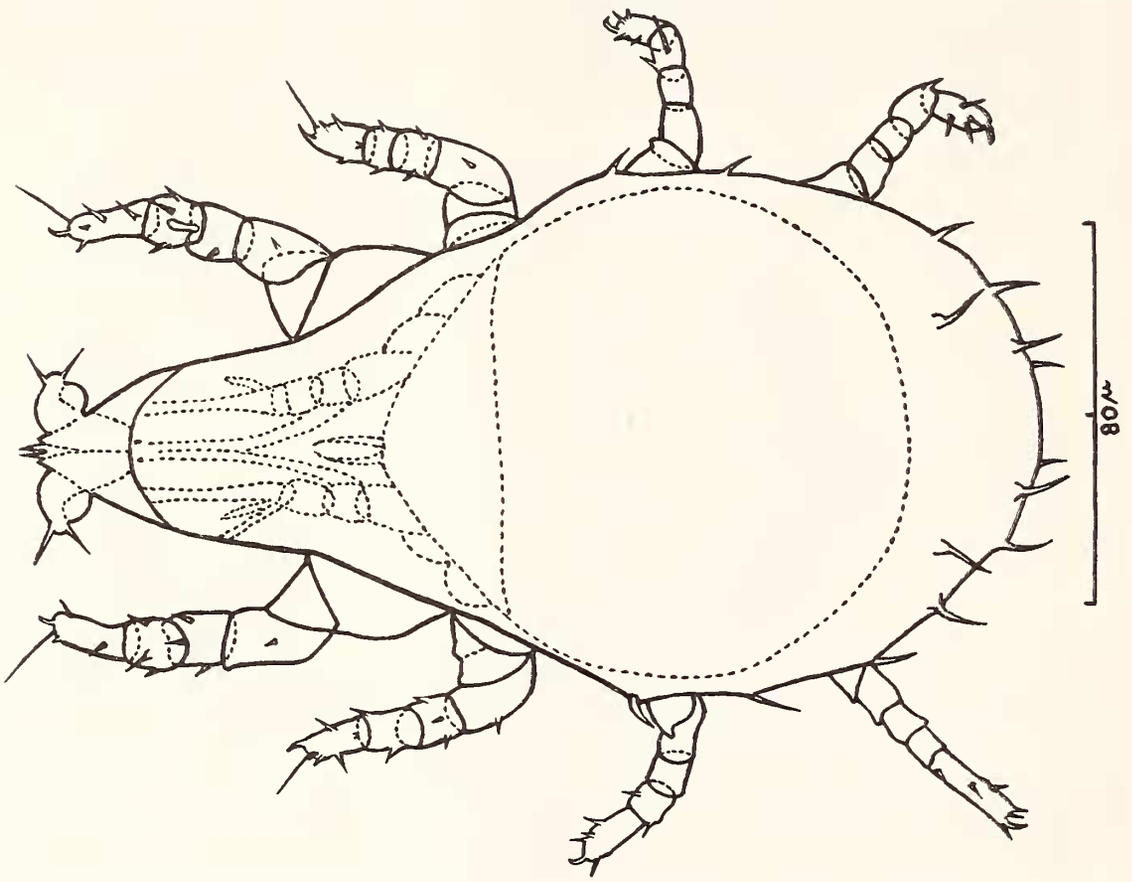

Fig. 2. Dorsal view showing the hypopus of *Histiostoma polypori* developing inside the resting protonymph.

and there is considerable movement of the legs. The old cuticle splits across the line dividing the proterosoma and the hysterosoma and the new stage emerges through the transverse slit. The old cuticle is rejected and left as an exuvia. Usually the posterior part of the old cuticle remains attached for a short time to the newly emerged mite after the anterior part has been pushed away by the anterior legs.

The emergence of the hypopus from the cuticle of the resting protonymph differs from that of the normal nymphs and adults in many respects. The brown dorsal shield of the hypopus makes

it very easy to detect this stage inside the cuticle of the resting protonymph. The relatively long anterior legs are directed straight towards the gnathosoma of the old cuticle (Text-fig. 2). The period of activity is exceptionally short compared with that of the normal nymph or adult inside the old cuticle. The hypopus deftly emerges through the transverse slit without breaking the old cuticle and immediately moves away at an exceptionally quick pace. The shed cuticle is transparent, very delicate and collapses after the emergence. Unless the resting stage is transferred to a well moistened slide and the emergence observed under a binocu-

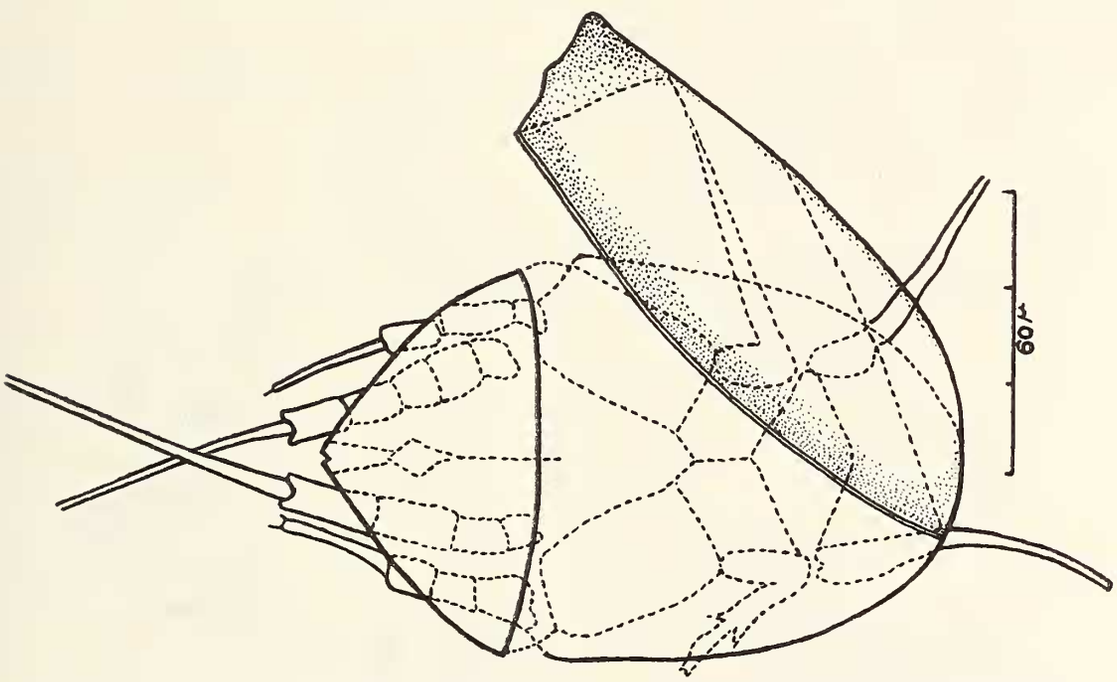

Fig. 3. The cuticle of the hypopus cast by the deutonymph of *Histiostoma polypori.*

lar microscope, it is easy to assume from mass observations of a culture in the cell that the old cuticle either disintegrates or is perhaps eaten by the newly emerged stage. My observations on the emergence of the hypopus from the cuticle of the preceding stage closely resemble those of Michael (1901), who studied *Tyroglyphus mycophagus* Mégnin.

The emergence of the deutonymph from the resting hypopus is preceded by the migration of tissues to the posterior region of the hysterosoma which is visible while the hypopus is still active. After the completion of de-differentiation of tissues, the cuticular shield splits along the line of division of the proterosoma and hysterosoma and emergence of the deutonymph as usually effected

by the cuticular shield of the hysterosoma also splitting along the left border and being pushed aside to lie slanting towards the right side, while still attached to the posterior end of the hysterosoma (Text-fig. 3). The shed cuticle of the deutonymph emerging from the resting hypopus is best seen when a thriving culture of mites in a petri dish is left to dry.

The Stages:

(a) The active larva:

The hexapod larva (Text-fig. 4), a characteristic stage in the life-cycle of members of the Acarina, soon after emergence from

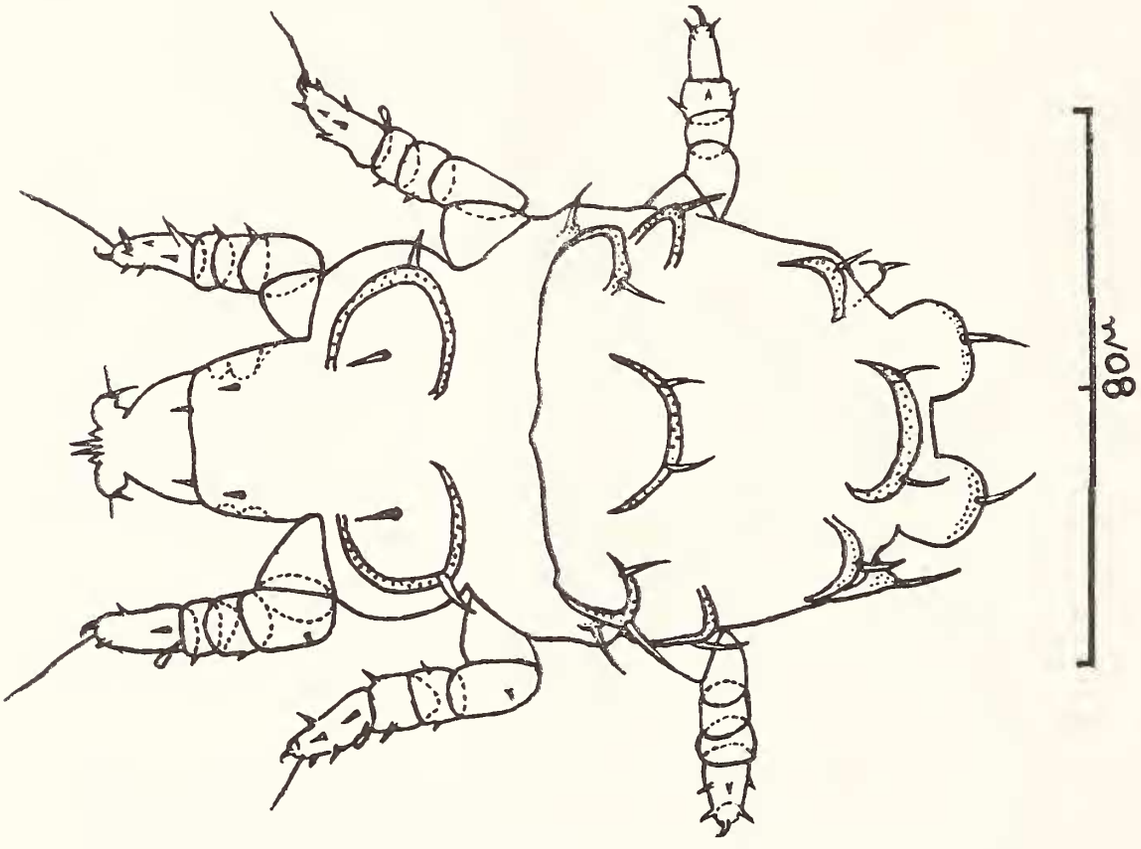

Fig. 4. *Histiostoma polypori.* Larva. Dorsal view.

the egg is hardly visible as it moves quickly over the moist filter paper. The fourth pair of legs is absent in the larval stage. The larva feeds continuously and as it increases in size the transparent nature of the body changes as the excreta, in the form of urates, are deposited as white masses in the body cavity. The deposition of urates is particularly heavy in the hysterosoma. When exposed to the temperatures of the laboratory, at 100% RH, in January 1949, the active larval phase lasted for a period

ranging from 24 hours to 84 hours with an average of 46.8 hours (Table 5). At a constant temperature of 26° C ± 1° C, 100% RH, the period of active larval life was greatly reduced with an average of 12.8 hours, although in some cases the larva was apparently unaffected by the warm conditions (Table 6).

TABLE 5

THE DURATION OF DIFFERENT STAGES OF *Histiostoma polypori* OBTAINED FROM FERTILIZED EGGS AND EXPOSED TO THE LABORATORY TEMPERATURES AND 100% RH.

Serial No.	Date of emergence of larval stage	Duration in hours					
		Larva		Protonymph		Deutonymph	
		Active	Resting	Active	Resting	Active	Resting
1	November 16, '48	19	17	22	22	30	20
2	January 15, '49	24	24	24	26	84	29
3	January 15, '49	24	24	24	26	84	29
4	January 18, '49	26	24	60	24	40	19
5	January 18, '49	.....	24	36	24	36	20
6	January 18, '49	24	24	36	36	.....	.....
7	January 20, '49	60	24	24	28	38	23
8	January 20, '49	84	23	24	24	45	24
9	January 20, '49	72	24	60	60	40	26
10	January 20, '49	60	24	24	40	42	22
Average	January, 1949	46.8	24	34.7	32	51	24

(b) The resting larva:

The attempt by the larva to find a suitable shelter is a prelude to the resting stage. In the cell the mite will either submerge itself in the food or will retire under a piece of disintegrated earwig cuticle. It was noticeable that the pace of the active larva was reduced and already there were signs of changes taking place within the body. As the soft tissues retreat from the legs and migrate into the hysterosoma, the legs, now cuticular cells, remain attached to the old body cuticle. The resting stage, which is completely immobile, is thus easily detected by the transparent proterosoma and an opaque hysterosoma. It is clear that the process is gradual since the first sign of a migration of tissues are observed in the gnathosoma when the larva is still active. When a settled larva is disturbed, it will sometimes move from the site very slowly before resettling. When histolysis is ad-

vanced the larva is incapable of such movement. The opaque mass of material in the hysterosoma is gradually re-differentiated into the eight-legged protonymph. When the resting stages are mounted in polyvinyl alcohol, or even water, it is possible to observe the different stages in the growth of the new individual. As far as one could judge, the period of time required for the transition phase from the beginning of the resting stage to the

TABLE 6

THE DURATION OF DIFFERENT STAGES OF *Histiostoma polypori* AT 26° C ± 1° C AND 100% RH.

Serial No.	Young from Fertilized (F) or unfertilized (UF) ♀	Duration in hours					
		Larva		Protonymph		Deutonymph	
		Active	Resting	Active	Resting	Active	Resting
1	UF	7	7	7	7	10	7
2	UF	48	14	16	6	8	6
(exception)							
3	F	15	10	.....	10	8	12
4	F	21	9	9	10	10	9
5	F	21	9	9	10	10	9
6	F	8	8	10	6	8	6
7	F	9	7	8	6	8	6
8	F	9	8	8	10	14	10
9	F	.....	12	10	6	8	6
10	F	10	8	8	6	8	6
11	F	.....	7	7	7	10	7
12	F	9	8	8	8	14	8
13	F	.....	.....	12	12	14	10
Average (for young from fertilized eggs)		12.8	8.6	8.9	8.3	9.8	8.0

time the newly-formed individual emerged was about 23 to 24 hours at the laboratory winter temperature, at 100% RH (Table 5). At a constant temperature of 26° C ± 1° C and 100% RH, the time required was reduced to an average of 8.6 hours (Table 6).

(c) The active protonymph:

The eight legged protonymph (Text-fig. 5) on emergence from the larval cuticle is about the same size as the fully-grown larva. But it is more elongated and, although in miniature it resembles

the appearance of the adult, the cuticle is much less tuberculate than that of the larva of the deutonymph. However, as the nymph grows, deposits of urates accumulate in the body cavity. Like all stages the active protonymph feeds continuously and increases in length from about 179μ to 242μ. In the moist cell at the laboratory temperature of January, 1949, and 100% RH, the active protonymph stage lasts an average of 32 hours with a minimum of 24 hours and a maximum of 60 hours (Table 5);

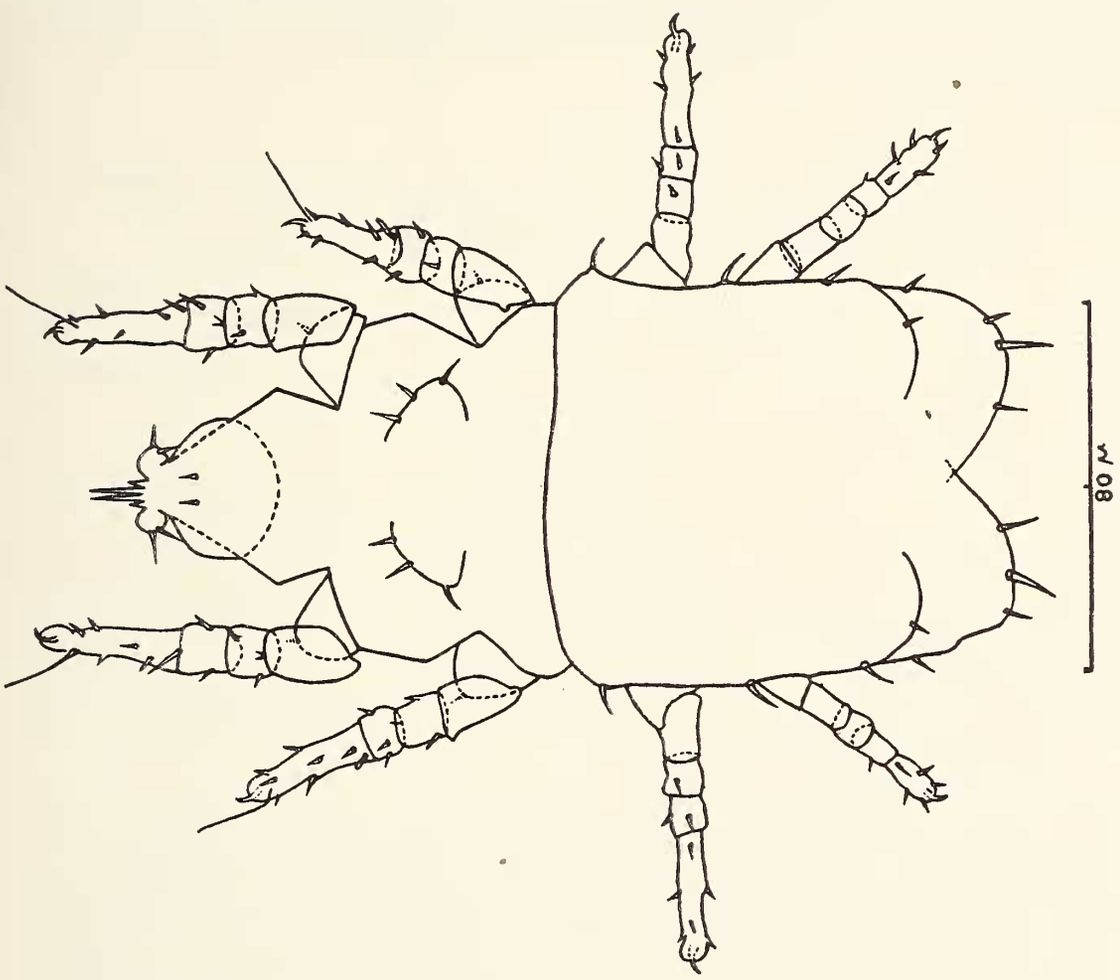

Fig. 5. *Histiostoma polypori.* Protonymph. Dorsal view.

but the time is greatly reduced at 26° C ± 1° C, 100% RH, to an average of 9 hours, with a minimum of 7 hours and a maximum of 16 hours (Table 6).

(d) The resting protonymph:

On approaching the resting conditions the behaviour of the active protonymph resembles that of the larva. The period of transition at the laboratory temperatures, at 100% RH lasts an average of 32 hours, with a minimum of 24 hours and a maximum

of 60 hours (Table 5). At 26° C ± 1° C, 100% RH, it only takes an average of 8.3 hours, with a minimum of 6 hours and a maximum of 12 hours (Table 6). Particularly characteristic of the later resting stages, including that of the protonymph, is the dull glassy appearance of the cuticle, resembling ground glass. The migration of tissue cells into the hysterosoma follows the same pattern, but the tissues may give rise either to the normal deutonymph or the extra-specialized hypopus. The production of the hypopus is indicated by a typically pointing and somewhat longer white proterosoma and later the rosy-brown colour of the dorsal shield.

TABLE 7

THE DURATION OF TRANSITION OF THE HYPOPI OF *Histiostoma polypori* EXPOSED TO THE LABORATORY TEMPERATURE AND 100% RH.

Serial No.	Date of resting of hypopus	Approximate duration in hours
1	October 2, '48	24
2	October 6, '48	23
3	October 6, '48	23
4	October 6, '48	26
5	November 16, '48	31
6	November 16, '48	33
7	November 16, '48	36
8	November 16, '48	48

(e) The resting hypopus:

On approaching the resting condition the behaviour of the active hypopus (Text-fig. 9) resembles that of other stages, e.g. larva, protonymph and deutonymph; the hypopus is very active and searches for a suitable place in which to settle. A feature of the resting position of the hypopus is the humped nature of the dorsal shield owing to a well marked curvature in the region of the anterior part of the hysterosoma. The anterior two pairs of legs are stretched closely forward, the first pairs usually crossing each other in front, and the posterior two pairs of legs are stretched outwards on the sides instead of being tucked underneath as is typical in the case of active hypopus attaching to the smooth surface of the host. As would be expected, the sucker apparatus of the hypopus is non-functional at the time of its rest-

ing and hence the resting hypopus can be easily removed from its resting place.

The period of transition at the laboratory temperatures of October and November 1948 and 100% RH lasts between 23 and 48 hours (Table 7). At 26° C ± 1° C, 100% RH, it only takes from 14 to 18 hours with an average of 16 hours (Table 8).

TABLE 8

THE DURATION OF TRANSITION OF THE HYPOPI OF *Histiostoma polypori* AT 26° C ± 1°C AND 100% RH.

Serial No.	Approximate duration in hours
1	14
2	16
3	16
4	18
5	14
6	18
7	16
8	15
9	17
Average	16

The resting hypopus is recognized by the appearance of whitish areas, formed by the migration of tissue cells into the hysterosoma, which contrast against the transparent brown cuticle. The deutonymphal stage emerges from the resting hypopus.

(f) The active deutonymph:

Nymph II or the deutonymph (Text-fig. 6) will emerge either from the resting protonymph or the resting hypopus. This stage when fully grown closely resembles the adult (Text-figs. 7 and 8). It is distinguished from the protonymph by the stouter appearance of the legs and the pronounced tubercles of the cuticle, whereas it differs from the adult, apart from size, by the presence of only a trace of developing genitalia and in the position of the suckers. At the laboratory temperatures of January, 1949, and 100% RH, the deutonymph remains active for an average of 51 hours with a minimum of 36 hours and a maximum of 84 hours (Table 5). At 26° C ± 1° C, 100% RH, the average was 9.8 hours, with a minimum of 8 hours and a maximum of 14 hours (Table 6).

At a somewhat advanced state of the deutonymph, one can well

predict from the shape and size of the body whether it will be a male or a female.

(g) The resting deutonymph:

On approaching the resting conditions the behaviour of the deutonymph resembles that of the larva, protonymph and hypopus. The period of transition at the laboratory temperature of January 1949, at 100% RH, lasts an average of 24 hours, with a minimum of 19 hours and a maximum of 29 hours (Table 5).

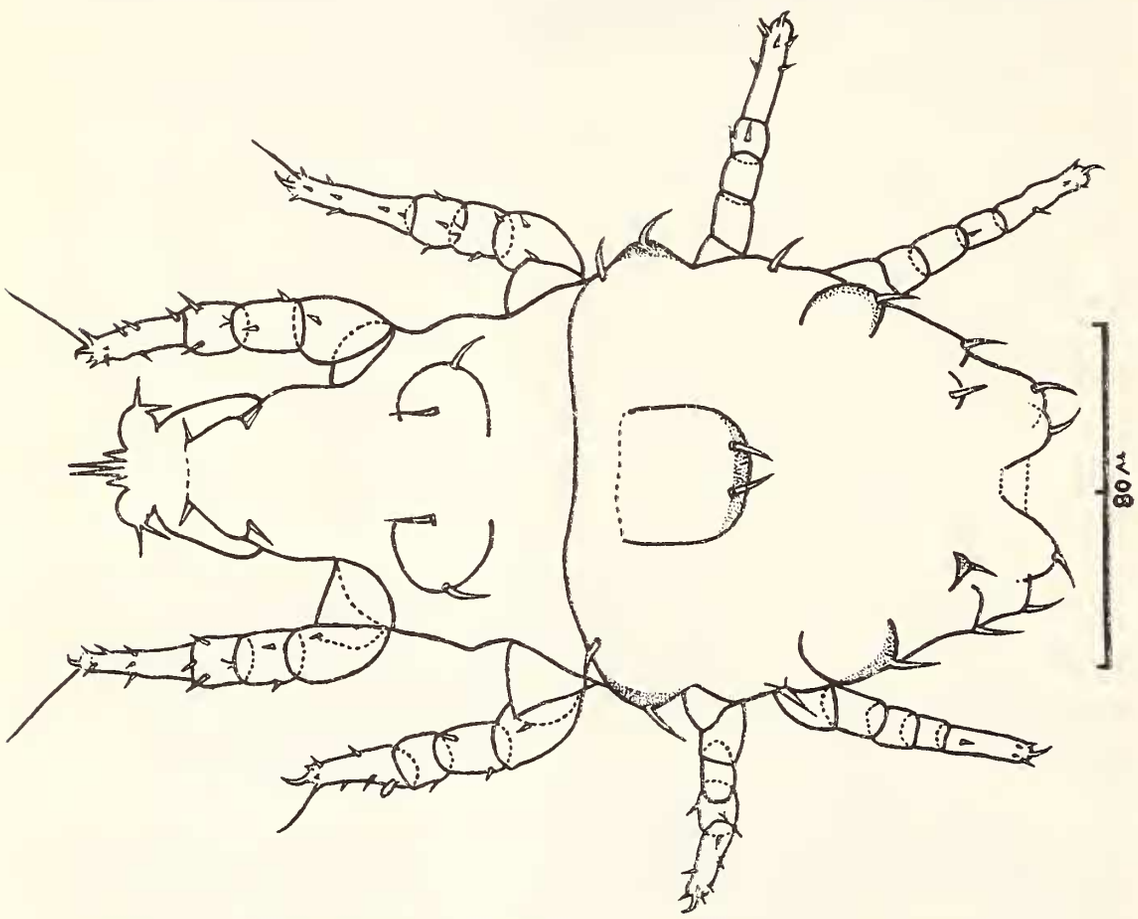

Fig. 6. *Histiostoma polypori.* Deutonymph. Dorsal view.

At 26° C ± 1° C, 100% RH, it only takes an average of 8 hours with a minimum of 6 hours and a maximum of 12 hours (Table 6). The migration of tissue into the hysterosoma follows the same pattern, but the redifferentiation of the tissues may give rise either to the male or the female adult, although of course, long before the transitional period, the shape of the active deutonymph indicates whether it will be a male or a female.

(h) The adult male:

The males which are about 263μ to 358μ are decidedly smaller than the females. The general shape of the body differs funda-

mentally from that of the female (Text-figs. 7 and 8). The tubercles of the body present a very rough surface. The stout nature of the legs is well pronounced compared with that of the female or deutonymph. The males are much more tenacious and long-lived than the females (Tables 9, 10 and 11). In the laboratory temperatures of January 1949 and 100% RH, the average length of life was 48 days, with a minimum of 26 days and a maximum of 63 days. No difference however was noticed in the survival periods of males derived from fertilized and unfertilized

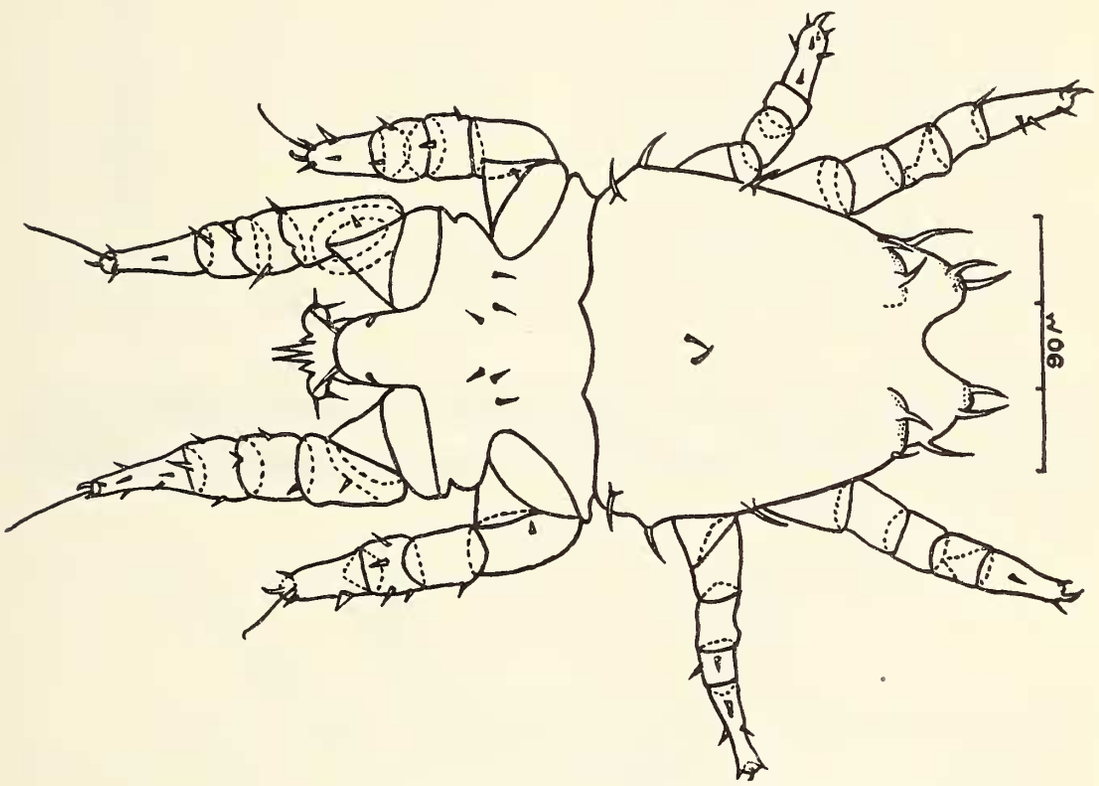

Fig. 7. *Histiostoma polypori.* Male. Dorsal view.

eggs (Table 9). Even in food on which fungus is growing the males are able to thrive either on fungus spores or apparently without food. They can also live immersed under water for a considerable length of time.

The various stages practically pass their whole existence almost immersed in the fluid upon which they subsist. Hirst compared the moisture-loving Tyroglyphoid mites floating in the liquid with living plankton in the sea (Vitzthum, 1932). Vitzthum (1932) stated that they are supported by the surface film of the liquid mass, and the secretion of oily substances over their bodies protected them from too excessive a contact with the liquid. Be-

TABLE 9

SURVIVAL PERIODS OF MALE OF *Histiostoma polypori* AT THE LABORATORY TEMPERATURES AND 100% RH.

Serial No.	Date of emergence of adult	Origin from fertilized F) or un-fertilized (UF) egg	Length of life in days
1	November 18, '48	UF	39
2	November 24, '48	F	36
3	November 24, '48	F	51
4	November 26, '48	F	60
5	November 27, '48	F	61
6	December 14, '48	UF	46
7	December 15, '48	UF	55
8	December 16, '48	UF	39
9	January 11, '49	F	26
10	January 11, '49	F	32
11	January 15, '49	UF	52
12	January 18, '49	F	61
13	January 16, '49	F	63
Average			48

sides it appears, in the case of *H. polypori,* that very little oxygen is required for their respiration or that they respire anaerobically, to some extent.

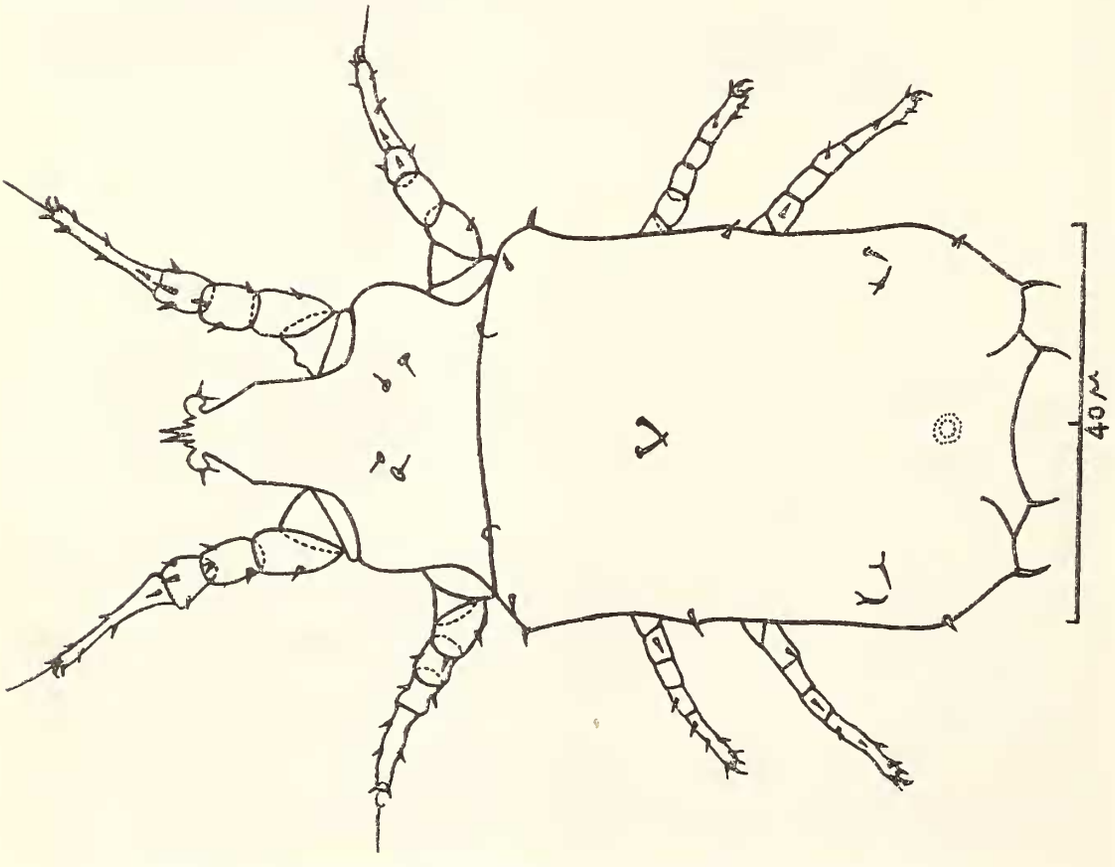

Fig. 8. *Histiostoma polypori.* Female. Dorsal view.

TABLE 10

SURVIVAL PERIODS OF THE FEMALE OF *Histiostoma polypori* AT THE LABORATORY TEMPERATURE AND 100% RH.

Serial No.	Date of emergence of adult	Origin from fertilized egg (F) or hypopi (H)	Length of life in days
1	October 4, '48	F	17
2	November 18, '48	F	16
3	November 12, '48	F	12
4	November 21, '48	H	9
5	November 22, '48	H	14
6	January 6, '49	F	18
7	January 10, '49	F	16
8	January 11, '49	F	10
9	January 11, '49	F	19
Average			14.6

As the male grows old, it becomes less active and more white with a tinge of faint brown in color.

(i) The adult female:

The body length of the female varies from 410μ to 547μ and is decidedly larger than the male. The shape of the hysterosoma

TABLE 11

LENGTH OF LIFE OF THE FEMALE OF *Histiostoma polypori* AT 26° C ± 1° C, AND 100% RH.

Serial No.	Origin from fertilized (F) or unfertilized (UF) egg or hypopus (H)	Length of life in days
1	H	6
2	F	18
3	F	13
4	H	17
5	H	9
6	UF	7
7	F	9
8	UF	14
9	UF	6
10	F	16
11	F	4
12	UF	12
13	F	4
14	F	12
15	F	14
Average		10.7

of the female (Text-fig. 8) is rectangular, in contrast to the somewhat triangular and bi-fid shape of that of the male.

The female is less hardy and short lived than the male (Tables 10 and 11). At the laboratory temperature of October 1948 to January 1949 and 100% RH, the average length of life was 14.6 days, with a minimum of 9 days and a maximum of 19 days. This figure, when compared with the average survival period of the male of 48 days, with a minimum of 36 days and a maximum of 63 days, is much shorter. At 26° C ± 1° C and 100% RH, the average length was 10.7 days, with a minimum of 4 days and a maximum of 18 days (Table 11).

The female cannot endure the growth of fungus in the cell in which it is reared, when compared with the high endurance of the

TABLE 12

DURATION OF THE LIFE-CYCLE OF *Histiostoma polypori* REARED IN THE LABORATORY AT DIFFERENT TIMES OF THE YEAR AT 100% RH.

Date on which eggs were laid	Condition of temperature	Number of days from egg to adult
Mid-November 1948	Laboratory temperature	9
Mid-January 1949	Laboratory temperature	13–16
Mid-April 1949	Laboratory temperature	6–8
.....	Constant temperature of 26° C ± 1° C.	3

male in such a situation. Food, especially fresh food, appeared to have a profound effect on the longevity and egg-laying of the female. If the female is kept in a moist cell without food, fungus soon grows on it and it succumbs to the infection; whereas, on the other hand, the male lives for a comparatively long time without food, even though fungus grows round about.

When the females are mature, eggs can well be seen through the transparent cuticle. However, they are sometimes confused with the uric acid crystals secreted into the body cavity. A maximum of three somewhat well-developed eggs have been seen inside the body of the individual female.

The female, as well as all stages of this species of mite, feign death when touched or disturbed.

Duration of Stages:

Since the duration of the different stages depends upon the temperature, it will vary according to the time of the year (Table 12).

The duration of the life-cycle as a whole will also vary in the same way (Table 13).

At the laboratory temperature of January, 1949 and 100% RH, the life-cycle was completed on the average in 14.5 days, with a minimum of 13 days and a maximum of 16 days, whereas at a constant temperature of 26° C ± 1° C and 100% RH, the average time was 3 days, with a minimum of 3 days and a maximum of 3.8 days (Table 13).

TABLE 13

THE DURATION OF THE LIFE-CYCLE (IN HOURS) INCLUDING THE DIFFERENT STAGES OF *Histiostoma polypori* AT THE LABORATORY TEMPERATURE OF JANUARY, 1949 AND AT A CONSTANT TEMPERATURE OF 26° C ± 1° C AND 100% RH.

	Laboratory temperature 100% RH.			Constant temperature, 26° C ± 1° C, 100% RH.		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Incubation of egg	85	28	110	20.5	10	40
Active larva	46.8	24	84	12.8	9	21
Resting larva	24	23	24	8.6	7	12
Active protonymph	34.7	24	60	8.9	9	12
Resting protonymph	32	24	60	8.3	6	12
Active deutonymph	51	36	84	9.8	8	14
Resting deutonymph	24	19	29	8	6	12
Pre-oviposition period of ♀	57	24	108	15	8	20
Length of life of ♀ in days	14.6	10	19	10.7	4	18
Length of life of ♂ in days	48	26	63	.....	.....	.....
Complete life-cycle from egg to adult (egg-laying) in days	14.5	13	16	3	3	3.8

Note: The hypopus stage is not included since the actual phase of this stage fluctuates greatly in respect to environmental conditions. It will resist adverse conditions for long periods and will change to deutonymph quickly if conditions are favorable. For the length of time taken by the transitional stage of the hypopus see Tables 7 and 8.

The Hypopus Stage:

The hypopus stage is of great biological interest, in view of its hardiness and the role it plays in the distribution of the species.

The hypopus is interpolated between nymph I and nymph II, and after resting will give rise to the deutonymph. In the case of *H. polypori* the hypopus is an active, mobile form for migration and for surviving in unfavourable conditions.

The hypopus (Text-fig. 9) is somewhat shorter and broader

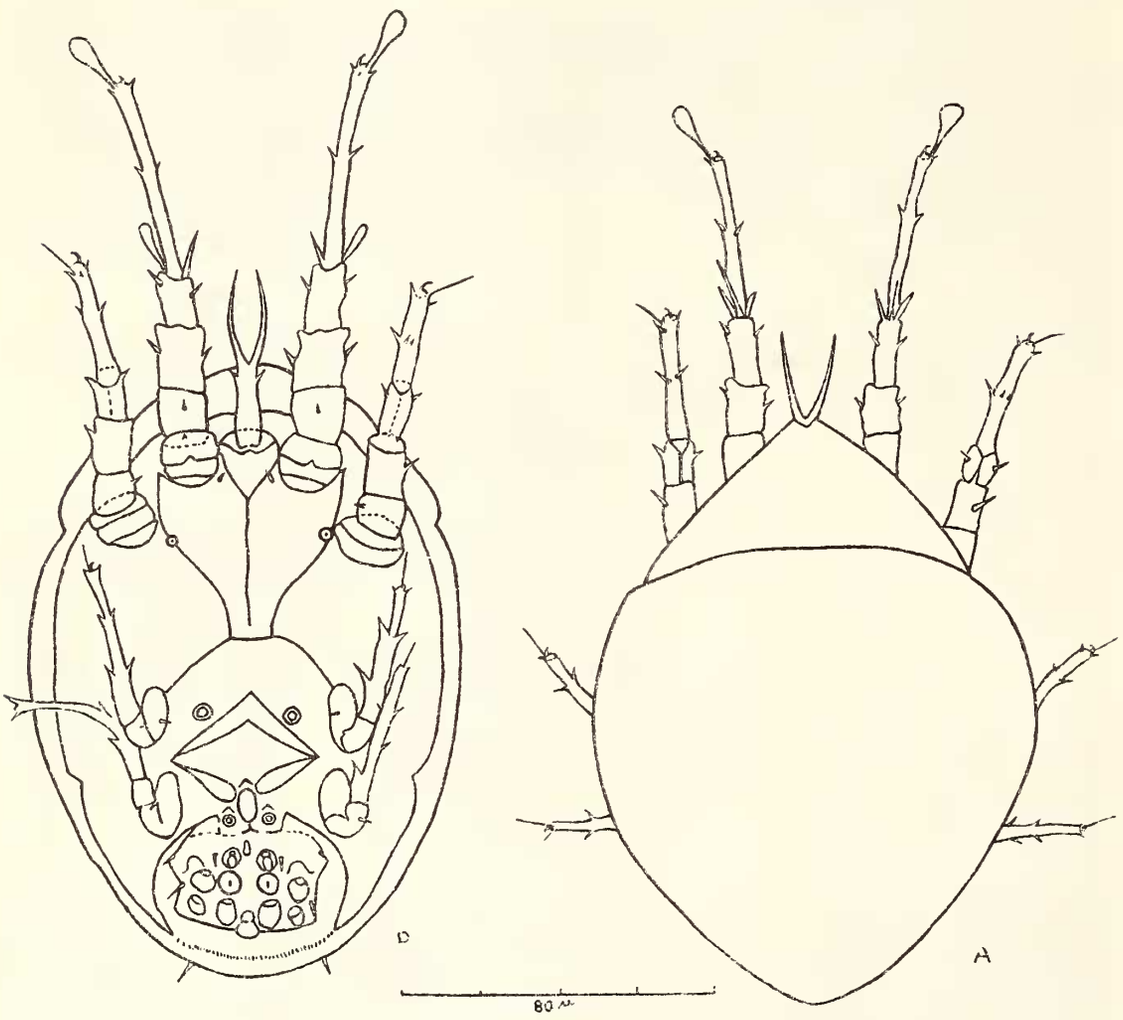

Fig. 9. *Histiostoma polypori.* Hypopus. A, Dorsal view; B, Ventral view.

than the protonymph, much more heavily chitinized and the dorsal surface covered by the carapace is usually of a reddish-brown color and shield-shaped. On the ventral surface of the body, near the posterior end, is a group of 10 suckers arranged in pairs upon a highly chitinized "sucker disc" or "plate," besides 6 more suckers arranged as shown in Text-fig. 9. These suckers are used by the hypopus in securing attachment to its "carrier host" for migratory purposes. The anterior two pairs of legs, especially their tarsi, are abnormally long and typically carried in front of the body. There are apparently no functional

mouthparts, this stage being an adaptation for the purpose of migration through attachment to *F. auricularia.* The length of time occupied by the hypopial instar varies considerably and the hypopi are able to withstand much more extreme conditions than any other stage. Normally, hypopi undergo ecdysis in about one or two days and the total length of the life-cycle may thus be increased by this amount.

When disturbed the hypopus retracts the third and fourth pair of legs and stretches the anterior two pairs of legs forwards and feigns death. They always occupy the upper portion of a container e.g. in a bottle, the underside of the cork in a glass dish, the underside of the glass cover.

When immersed under water, the hypopus is unable to retain its firm hold upon the host or a smooth glass surface with its "suckers" for any length of time. It soon releases its hold and will rise to the surface and float upside down.

The hypopus will often climb on to the dorsal shield of another and then actively wave its fore-legs.

Considerable variation of size exists in the hypopi obtained from the same culture. However, both small and large types of hypopi gave rise to deutonymphs which became either male or female adults. Evidence suggested that the size of the hypopi depended to some extent on the size of the preceding protonymphs as they passed into the resting stage.

Influence of Physical Factors on Hypopus Formation:

Solomon (1946) summarized our knowledge about the formation of hypopus as follows:

"The factors determining hypopus formation have been discovered only in part. In some cases it seems that intrinsic (probably genetic) factors predominate, in others extrinsic factors (e.g., lack of suitable food) seem to predominate. In fact, the position is far from clear, and appears to be different in different species, possibly in relation to the type of hypopus concerned."

In the case of *H. polypori,* lack of food appears to have profound effect on the formation of hypopus. When food was plentiful, not a single hypopus was formed. When food was scarce, some protonymphs instead of changing into deutonymphs formed hypopi. However, I do not consider food to be the only

factor controlling the formation of hypopus. Even when practically no food was given formation of hypopi as well as males and females was observed.

Humidity appeared to be the only factor responsible for stimulating the transformation of the hypopus to the deutonymph. If hypopi were kept at a high humidity but without food, they changed into deutonymphs. When kept immersed under water, the hypopi changed into deutonymphs, though not so quickly as they did when exposed to the moist conditions of the culture cell.

TABLE 14

MEASUREMENTS OF EGGS AND INCREASE IN SIZE IN DIFFERENT ACTIVE STAGES IN THE LIFE-CYCLE OF *Histiostoma polypori* AT THE LABORATORY TEMPERATURE AT 100% RH (EXCEPT IN HYPOPI, THE LENGTH OF IDIOSOMA IS GIVEN).

Serial No.	Length of eggs when laid	Active larva	Active proto-nymph	Active deuto-nymph	Male	Female	Hypopus (total length)
1	84 μ	126 μ	147 μ	205 μ	210 μ	358 μ	158 μ
2	89 μ	126 μ	152 μ	210 μ	231 μ	358 μ	158 μ
3	89 μ	127 μ	152 μ	210 μ	258 μ	363 μ	162 μ
4	91 μ	128 μ	158 μ	215 μ	263 μ	373 μ	163 μ
5	94 μ	129 μ	158 μ	216 μ	263 μ	379 μ	163 μ
6	94 μ	137 μ	158 μ	220 μ	294 μ	386 μ	167 μ
7	94 μ	139 μ	159 μ	230 μ	300 μ	389 μ	168 μ
8	105 μ	142 μ	161 μ	233 μ	305 μ	433 μ	168 μ
9	105 μ	142 μ	179 μ	242 μ	305 μ	473 μ	179 μ
10	110 μ	147 μ	200 μ	242 μ	305 μ	477 μ	179 μ
Average	95.5 μ	134.3 μ	162.4 μ	222.3 μ	273.4μ	398.9 μ	166.5 μ

Growth Rate:

The eggs when laid are about 89μ long and 59μ at their greatest width. Owing to the inhibition of water and the tension of the growing embryo, they are as large as the smallest larva—about 126$\mu \times 84\mu$ at the end of the incubation period. The measurements of the different stages in the life cycle are given in Table 14. The variation of size is however primarily dependent on the supply of food.

PARTHENOGENESIS

There are few authentic records of the occurrence of parthenogenesis among members of the Acarina, especially, so far as the writer is aware, among those confined to the Tyroglyphoidea.

Jary and Stapley (1936) discovered parthenogenetic reproduction in *Histiostoma rostroserratum* and Stolpe (1938), based on his studies of *H. genetica,* suspected the probability of parthenogenetic development, in mites.

Females originating from hypopi were segregated and given no opportunity of mating. These unfertilized females laid eggs which invariably produced adult males. The results resembled and recalled the phenomenon of the parthenogenetic eggs of Arthropods producing only males. Similar results were obtained by Jary *et al.* (1936) in their study of parthenogenesis in *H. rostroserratum* and by Cooper (1937) in the grass mite *Pediculopsis graminum* (Reut.) (Tarsonemidae). Although artificially segregated females will produce eggs parthenogenetically, it is reasonable to suppose that the phenomenon will also occur in the natural environment. A female will normally begin laying within 48 hours after emerging from the resting deutonymph skin. So, should males not be available as the female emerges, unfertilized eggs will be laid within 48 hours. Should an egg-laying female become isolated in the field, it will live long enough possibly to be later fertilized by males of its own progeny. In the laboratory it was noticeable that unfertilized females occasionally laid fewer eggs (Table 2, items marked with *), but otherwise their appearance was normal. Of the batches of unfertilized eggs a great many did not survive even when they were exposed to favorable conditions of temperature and humidity. Occasionally an unfertilized female would lay no eggs at all.

SEX-RATIO

It was significant that the population of a thriving culture of mites was usually predominated by males. This suggested that a good many of the females had failed to mate and so gave rise to an all male parthenogenetic progeny, which accounted for an increase in the number of males in the culture. Occasionally the reverse was true because some colonies were predominated by females. This was more noticeable when stock cultures were examined.

The preponderance of males in a culture of *H. polypori* may also originate from normally fertilized eggs. Of seven batches of fertilized eggs reared in the laboratory at 100% RH, the ratio obtained was 76% males and 24% females.

TABLE 15

THE NUMBER OF MALES AND FEMALES OF *Histiostoma polypori* OBTAINED FROM SEVEN BATCHES OF FERTILIZED EGGS REARED TO THE ADULT STAGE IN THE LABORATORY TEMPERATURE AT 100% RH.

Serial No.	Number of males	Number of females
1	9	9
2	20	14
3	14	2
4	6	1
5	2	3
6	64	32
7	87	4
Total	202	65

ACKNOWLEDGEMENTS

This work was carried out under the supervision of Dr. B. M. Jones at the Department of Zoology, University of Edinburgh, Scotland, during the tenure of an overseas scholarship from the Government of Orissa (India). The author is extremely grateful to the former for advice and guidance and to the latter for the financial aid. I also record my sincere thanks to Prof. James Ritchie for laboratory facilities and helpful suggestions. It is also a pleasure to thank the many members of the Zoology Department of the Edinburgh University for their many kindnesses and the Royal Entomological Society, London, for the loan of literature.

SUMMARY

The mites, *Histiostoma polypori* (Oud.) were reared in special perspex cells 4 cm. square and 0.3 cm. deep. The actual rearing chamber was a central bevelled hole 1.7 cm. in diameter enclosed by black filter paper on one side and a coverglass on the other. The mites were kept at 100% RH and either at the laboratory temperature or a constant temperature of 26° C ± 1° C. The decomposing remains of earwigs and horse flesh provided an admirable rearing diet. Colonies or individuals in the cells were easily examined under the binocular microscope. The different stages as required were mounted in water, lactic acid or polyvinyl alcohol.

The male will clasp the female deutonymph in the active and resting phases and will mate with the adult female immediately after it emerges.

The eggs were laid within 24 to 108 hours, with an average of 57 hours, after mating. At 26° C ± 1° C, 100% RH, a single female will lay 40 to 110 eggs. The eggs are laid singly or in groups of two or three but in a large colony the eggs are found aggregated in masses, either upon or around the food. The chorion is transparent and the eggs are opaque in appearance.

The incubation period varies according to the time of the year. At 26° C ± 1° C, 100% RH, the period ranges from 13 to 40 hours, the average being 20.5 hours.

The new stage is formed within the cuticle of the preceding stage. Histolysis is followed by de-differentiation. The old cuticle splits transversely between the proterosoma and the hysterosoma to allow the emergence of the new stage. The old cuticle remains as an exuviae. The hypopus deftly emerges through the transverse slit and the process is a short one. On emerging from the hypopial cuticle the deutonymph will climb out of the hard cuticular case—the dorsal shield which is pushed aside after splitting along the line of the division of the proterosoma and hysterosoma and along the lateral borders.

The egg and larval stages are followed by two nymphal stages leading to the adult. The specialized extra nymph or hypopus occurs spasmodically between the two normal nymphal stages.

The duration of the stages depends primarily on the temperature. The life-cycle varies according to the time of the year. At a constant temperature of 26° C ± 1° C, 100% RH, it takes 3 to 4 days. At the laboratory temperatures during the winter months it takes about 2 weeks.

The duration of the hypopus stage varies considerably. When exposed to the favorable conditions of a culture cell the hypopi will soon pass into the transition stage but they will also remain as typical hardy hypopi indefinitely, should unfavorable conditions be prolonged. Both small and large hypopi will change into deutonymphs.

Scarcity of food and dry conditions will accelerate the formation of hypopi whereas a high humidity will cause hypopi to pass into the resting stage.

The variation of size of the different stages depends primarily on the temperature and the availability of food.

H. polypori will produce parthenogenetic eggs which will give rise to male individuals.

Cell cultures predominated by males whereas occasionally the reverse was true of stock cultures. More males will be produced because the females of a colony are not always fertilized. But it was also shown that males will predominate by 76:24 in colonies produced only by fertilized females.

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(*Continued from page 40*)

The corpus allatum, about which it once seemed that everything was known, is now, Dr. Scharrer reported, less satisfactorily understood than the prothoracic gland. It does produce the same type of hormone in immature and adult insects, but the action of the hormone differs at these two periods in the life of the animal. In the larva, the corpus allatum is the source of "juvenile" hormone, which in combination with the products of the prothoracic gland causes the nymphal moult. In the adult, the corpora allata cause normal development of eggs and accessory sex glands.

Neurosecretory cells of the pars intercerebralis have fibers passing by a

(*Continued on page 79*)